

PROBLEMATIC ISSUES OF AUTOMATION OF METEOROLOGICAL OBSERVATIONS: UKRAINIAN EXPERIENCE

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Abstracts. The Hydrometeorological Service of Ukraine has undertaken efforts for putting in operation of modern technologies for hydrometeorological measurement, first of all, automated measurement stations. The target state program aimed at technical re-equipment of the Hydrometeorological Service with modern technologies has been implemented in the country for 10 years. The organization of the development and implementation of this program as well as obtained results obtained are considered in the article. The special attention is paid to the problematic issues that arose in the course of this work, in particular, achievements and gaps in the results.

Key words: hydrometeorological observations, automation of measurements, problematic issues

1. Introduction.

Improving the quality of hydrometeorological information, forecasting and servicing the sectors of economy and population requires a technical upgrade of the network of observation through the automation of measurements. The Hydrometeorological Service of Ukraine has undertaken efforts for putting in operation of modern technologies for measurement, first of all, the automated measurement stations. The work in this area has been started in the middle of 1990s, it is continuing now and it will be continued in the next years. A number of results related to experiences of organization of elaboration, production, putting in operation and exploitation of mentioned equipments in the Ukrainian Hydrometeorological Service have been obtained. These results were summarized as the researches which were carried out by the Ukrainian Hydrometeorological Institute.

2. The aim of this article is presenting the experience of the Hydrometeorological Service of Ukraine in the area of organization of work of automation of network of hydrometeorological measurements.

The special attention is paid to the problematic issues we met on this difficult path. Besides, the measures which were undertaken by the Hydrometeorological Service to overcome the mentioned issues are considered in the paper.

3. Used methodology and data.

The study is based on results of analysis of:

- the implementation of programs of technological development of the Hydrometeorological Service of Ukraine which were carried out during the period from the middle of 1990's;
- the experience of introducing and maintenance of modern equipment on observation networks of the Hydrometeorological Service

4. Results.

4.1. Why and how it all began.

The Hydrometeorological Service of Ukraine faced a problems of the equipping of observation networks with modern means of hydrometeorological measuring from the first years after its establishing in 1992.

There were the following issues:

- the most of existing technical means of measurement were developed in 1960-1970s. The automated stations, remote sensors technologies were practically absent. More than half of the devices were physically and morally obsolete and demanded their change;
- organizations and manufactures of hydrometeorological equipments were located outside Ukraine, mainly in Russia;
- it was necessary to solve the problem of technical re-equipment under conditions of insufficient budget financing.

In this situation, it was very important to develop and adopt a long-term strategy for the development of the Hydrometeorological Service which should include the issue of technical re-equipment of observation networks. The Strategy of Developing the Hydrometeorological Service of Ukraine for ten years period was elaborated by the State Committee of Ukraine for Hydrometeorology in 1993. In the area of technological development the Strategy provided with a number of measures aimed at: 1) establishing in Ukraine the Industry of producing the hydrometeorological instrumentation and equipments; 2) equipping the observation networks with the automated technical systems and technical systems for a remote reception of information; 3) strengthening a capacity-building of personal which will operate with new technologies.

During the development of this strategy, the following factors were taken into account: 1) the presence of a developed industrial complex in Ukraine, which had a rich experience of work for economy and defense needs; 2) the presence of significant scientific potential in the scientific and educational institutions of Ukraine; 3) the absence of necessary funds in the budget of the Hydrometeorological Service for a purchase the technologies abroad.

Taking into account the real economic situation in the country, the available scientific and production potential of Ukraine, the program focused approach was chosen as the main direction of technical and technological development of the Ukrainian Hydrometeorological Service, based on the development and implementation of targeted scientific and technical programs. This approach was implemented within the framework of the State Program for Scientific and Technical Re-equipment of the Hydrometeorological Observing System and the Basic Network for Observations of Environmental Pollution ("Meteorology" Program). This Program was adopted by the decree of the Cabinet of Ministers of Ukraine in 1996 for five years and was prolonged by the decree of the Cabinet of Ministers of Ukraine in 2001 for next five years. The total period of Program's implementation was 1996-2005.

Tasks on the technical re-engineering of the Hydrometeorological Service were also included in a number of others state and sectoral programs, in particular, the Climate Program of Ukraine, the Program of Informatization of Ukraine, the Program for the Improvement of the System for the Prevention of River's Floods, etc.

In a sense, the task was to make a technical revolution, the ultimate result of which was to create in Ukraine a high-tech branch of industry - the hydrometeorological instrumentation. It was assumed that the developed technologies would be used not only in Ukraine but also would be exported abroad.

More than forty modern automatic technical complexes, instruments and equipment for meteorological, hydrological and hydrochemical observations were designed by the Ukrainian producers in the frame of these programs. The technical characteristics of these instruments and equipments met the requirements of the World Meteorological Organization to the measurement accuracy, and their prices were lower on 15 - 20% than prices of corresponding foreign analogues.

Thus, the automated meteorological stations were designed and manufactured for measurements: at the aviation meteorological stations (AMAS-Avia-1, AMAS- Avia-2); at ground-based meteorological stations (AMS-S1, AMS-S2); on sea and river vessels (AMS-S).

Besides, the Ukrainian producers designed and manufactured the automated hydrological station (SAH) which also measures meteorological parameters - the air temperature and precipitation.

At present, the Hydrometeorological Service of Ukraine operates 12 automated meteorological ground-based network stations, 23 automated aviation meteorological stations and 43 automated hydrological stations, which measure meteorological parameters. Besides, Ukrainian producers developed the modern separate sensors of: air, soil and water temperature, wind speed, atmospheric pressure, meteorological range of visibility, amount and intensity of precipitation, water level in the river and lake, etc. These sensors can function in a composition of automated stations as well as independently.

In addition, the Hydrometeorological Service operates automated stations of foreign production:

- the automated aviation meteorological station (setting up in the Boryspil International Airport) and automated hydrological stations the produced by the “Vaisala oy” (Finland).
- the KRAMS automated aviation meteorological stations produced by Russia with meteorological sensors produced by the “Vaisal oy” (setting up in four airports);
- the automated hydrological station produced by “the Vaisal oy”;

In the process of automation of meteorological observations, several stages can be divided: 1) the development and approval by the Ukrainian Government of the Programs aimed the technological re-equipment of the Hydrometeorological Service; 2) developing the technical requirements to instruments and equipment as well as the calendar plans of their development; 3) the choice of performers of works on the development and production of new devices and equipment; 4) designing and producing new technologies; 5) putting in operation and operation of new devices and equipment.

In the process of implementing each stage of the Program had to face the difficulties, and seek solutions to overcome them. Some difficulties have been due to the lack of experience in organizing such a large-scale production of hydrometeorological technologies, but a number of problems were of a systemic nature and lay beyond the scope of possibility of their solved by participants involved in the implementation of programs. These issues will be considered below.

4.2. The stage of development and approval by the Government of Programs related to the technical re-equipment of the Hydrometeorological Service.

This stage required considerable effort from the Hydrometeorological Service in order to persuade the Government of the country that it is necessary to invest the significant budget funds in the development and production of Ukrainian hydrometeorological instruments and

equipment. The Hydrometeorological Service, together with the Ministry of Industry, sent a number of letters to the President of Ukraine, the Prime Minister of Ukraine with requests to invest in the creation of the native branch of hydrometeorological instruments making. A number of interagency meetings were also organized. During these meetings the representatives of the government bodies were got the detailed information about the urgency of re-equipment of the Hydrometeorological Service and the available opportunities of Ukrainian institutions and enterprises to elaborate and produce the hydrometeorological instruments and equipment.

The Hydrometeorological Service together with potential developers and manufacturers of technologies studied in detail the needs of the system of hydrometeorological observation and forecasting in modern technologies, the technical characteristics of foreign instruments and equipments, and made a feasibility study of the draft state program. It has been shown that the manufacture of devices and equipment in Ukraine will cost the state budget 15-20% less than the purchase of similar devices and equipment abroad. Besides, elaborated new technologies can be exported abroad that can be the source of receipt of foreign currency funds to the state budget of the country.

Only then was the Government's permission to develop the draft of the State Program for Scientific and Technical Re-equipment of the Hydrometeorological Observing System and the Basic Network for Observations of Environmental Pollution, which was approved by the Cabinet of Ministers of Ukraine in 1996. In general, it took 2 years to develop and approve the Program.

During 1997-1998, the Hydrometeorological Service also developed the Climate Program of Ukraine as well as some sections into other State Programs. These programs also provided for developing and manufacturing technologies of measuring, data processing, forecasting and warnings. The Programs were adopted by the resolutions of the Government of Ukraine.

4.3. Stage of developing technical requirements to instruments and equipment and calendar plans of their development.

The following factors were taken into account when developing the technical requirements for devices and equipment:

- the WMO and ICAO recommendations on the accuracy of measurement of meteorological values;
- the technical characteristics of devices and equipment developed by the well-known manufacturers of hydrometeorological equipment;
- the needs of providing a reliable transmission of observation data from the meteorological network to national and regional weather forecasting centers;
- the features of practical operation of technologies in different natural conditions of Ukraine;
- the wishes of the employees of the Hydrometeorological Service to ensure the convenience of working with devices and equipment;
- the ability to make advanced changes to the hardware and software of equipments in the process of their exploitation.

At this stage, it was also very important to draw up the clear calendar plans for developing prototype devices. The plans had to take into account needs of the Hydrometeorological Service in the fastest retrofitting of the observation networks on the one hand, and it to be closely linked to the total and annual amounts of funding foreseen for work on the other hand. This stage was one of the most complex and responsible as it required the specialists of the Hydrometeorological Service of Ukraine to study a large volume of special literatures and

experiences of others Hydrometeorological Services in order to articulate the exact equipment requirements.

4.4. Stage of selection of producers of technologies.

The selection of performers of work on the manufacture of devices and equipments was carried out on a competitive basis. In accordance with the Ukrainian legislation, price proposals from the manufacturers were the main criterion of tender procedure in a case of fulfillment of other technical requirements for the equipment.

At this stage, should be taken into account the fact that under complicated economic conditions in the country, the enterprises that did not have the appropriate qualifications often took part in tenders to obtain orders for the production of equipment. They offered a deliberately low cost of work. This required a preparation of tender documentation to indicate not only the technical requirements for the equipment, but also the requirements for the manufacturer, in particular, the availability of his experience of work, production facilities and equipment, etc. As time has shown, these precautionary measures have made it possible to significantly reduce the possibility of errors in the choice of equipment producers. Unfortunately, it was not possible to completely avoid errors in the choice of developers. In such cases, the contracts for works were interrupted and holding of new tenders were organized. Of course, this increased the cost of developing prototype devices and delayed the start of their serial production.

4.5. Stage of development and production of technologies.

Of course, this was the most responsible stage of the entire cycle of work. This stage required the closely cooperation and significant joint efforts on the parts of customer and performer of works to overcome problems that arose throughout the period of works on the development and manufacture of equipment. The problematic issues conventionally can be divided into the following groups: 1) organizational; 2) technological and 3) financial.

Organizational issues were mainly related to the organization of work in the Hydrometeorological Service for: 1) planning and controlling the elaboration of devices and equipment; 2) testing devices and equipment on observation networks; 3) obtaining a certificate of permission for their use in the work, 4) the introduction of new technologies into operation; 5) developing guides, manuals, others regulation manuals to use new technologies in the practical activity; 6) training specialists to work with new technologies.

In order to organize and control the implementation of this work a number of orders were issued by the Hydrometeorological Service. These orders regulated the interactions between consumer and developers, the rules for accepting work results as well as the rules of introducing new technologies in operation.

Technological issues concerned mainly developers and manufacturers of equipments. Despite the fact that virtually all of them had experience in the development and manufacture of electronic equipment, the area of development of hydrometeorological instrumentations was unfamiliar for them. Practically, every month there were working meetings of customer and developers of equipment dedicated to: 1) the consideration of state of works; 2) the specification of some requirements for the hardware and software of technical systems and devices; 3) the discussions of developer proposals to improve the technical characteristics of devices. In some cases, developers proposed to make changes to the equipment specifications, in particular, it was concerned sensors for precipitation measuring. Unfortunately, there were several cases when the customer was forced to terminate the contractual relationship with the developers, as the

developers was unable to offer effective technical solutions, and the development entered to a "deadlock".

Unfortunately, financial issues have a negative effect on the technical re-equipment of the Hydrometeorological Service during all years of Programs implementation. It is safe to say, that this problem has become a "chronic disease". The State Programs of Technical Re-equipment of the Hydrometeorological Service mentioned above envisaged two types of investments: 1) investment in the development of prototype technologies and 2) capital assets costs for the procurement of developed technologies that were adopted for implementation in practical operation. Unfortunately, during the period of implementation of programs, the first part of expenditures was financed only in the amount that did not exceed 40% of the planned financing. The capital assets costs did not stand out at all. In addition, funding the elaboration of technologies was uneven during the period of year. The basic funding has been allocated in the last quarter of year.

It complicated the work of both the customer and performers, caused delays, and sometimes ruining of terms of technologies development. This forced the Hydrometeorological Service to take measures aimed at minimizing negative consequences of such situation. In particular, the following measures were taken:

- priorities in elaborating technologies were established. Priorities have taken into account immediate needs of the Hydrometeorological Service in providing information, forecasts and warnings to authorities, sectors of the national economy and population;
- first of all, developing aviation meteorological technologies was financed. Two main factors predetermined such approach. The first factor was the need to ensure the safety of flights of civil aircraft. The technical equipment of aviation meteorological stations was very far from present needs of civil aviation;
- the opportunity to raise funds made by aviation meteorological organizations for meteorological servicing the civil aviation for the development and subsequent procurement of technologies was the second factor. It should be noted that civil aviation has been and remains the main source of additional financing for needs of the Hydrometeorological Service. Moreover, very often only aviation meteorological organizations have the capital assets costs to purchase the developed equipment;
- developing the automated meteorological stations for the basic observation network was attributed to the priority of the next level. It was supposed to start equipping a network of observations in regions where dangerous weather phenomena are often observed, in particular, in the Ukrainian Carpathians;
- among other priority directions of re-equipment it is possible to note the elaboration of technical complexes for upper - air observation and automated hydrological stations

Thanks to the measures taken, already three years after the start of the State Program of Technical Re-equipment, the network of hydrometeorological observations began to be equipped with domestic technical means of hydrometeorological measurements. The Government of Ukraine saw that the scientific institutions and enterprises of the country managed to lay the foundation for a high-tech branch of hydrometeorological instrumentation. At the suggestion of the Hydrometeorological Service, which was supported by the Ministry of Industry, the Government of Ukraine decided to extend the Program for another five years, until 2005. Thus, for 10 years it was possible to equip the Hydrometeorological Service with modern domestic technologies of meteorological observations, aviation meteorological observations, upper-air observations, hydrological observations, some kinds of air and water pollution observations.

4.6. Stage of putting in operation new technologies.

The important steps of this stage was to organize the proper testing of the developed technique which meets the requirements of national legislation in the area of metrology and standardization; obtaining permissions (state certificates) for their use, as well as training of personnel of the Hydrometeorological Service for work on new technologies.

In order to ensure proper testing of devices and equipment, the phase of introduction of new technologies into practical working was preceded by a phase of their experimental exploitation, which lasted from two up to six months depending on technology types and results of testing. During the period of experimental exploitation, defects in the hardware and software part of the equipment were identified and eliminated; according to the wishes of specialists of the hydrometeorological service, changes to the system for processing, storing and presenting data and were made. The considerable attention was paid to checking the work of systems of real-time data transmission from automated stations to the centers of hydrometeorological forecasting. It should be noted that those or other shortcomings in the work of new devices and equipment were detected in more than 50% of cases. Among the revealed shortcomings, deficiencies in the work of individual sensors prevailed - about 65% of all cases.

The deficiencies found in the operation of the devices and equipment in most cases were promptly eliminated by the manufacturers of the equipment in accordance with the test results and recommendations of the equipment users. However, there were cases when the manufacturer, in order to fulfill the customer's requirements, had to make changes to the principle of the operation of sensors, for example, precipitation measuring sensor. This delayed the introduction of new appliances and equipment in practical use, sometimes up to 9 - 12 months.

During this stage the engineers, technicians and observers of the Hydrometeorological Service were also learned to work with new equipment. Training was carried out according to the regional principle: in Kyiv for staff from the observation network of the northern and central parts of Ukraine, in Lviv - from the western part, in Kharkiv - from the eastern part and in Odesa - from the southern part of the country. The curriculums included a lecture course on theoretical issues of the use of modern hydrometeorological measurement technologies and practical work with new devices and equipment.

4.7. Achievements and gaps of the Program of technical re-equipment of the Hydrometeorological Service.

We can indicate the following principal Program's achievements:

- in Ukraine were mastered the development and production of high-tech technologies, namely, hydrometeorological sensors, devices, technical systems and equipment;
- equipping observation networks with Ukrainian hydrometeorological equipment, which allowed to improve the quality of hydrometeorological observations, forecasting and servicing;
- raise the professional level of the employees of the Hydrometeorological Service, which enabled them to work with modern technologies.

No doubt, the experience of exploitation of these technologies showed the efficiency of their operation for different purposes: meteorological servicing of a civil aviation; forecasting and warning weather-related hazards and so on.

At the same time, as a result of the implementation of the Program failed to solve two of the most important tasks of the Program:

- create in Ukraine a powerful branch of hydrometeorological instrumentation, which would not only meet the needs of the National Hydrometeorological Service, but also export its products abroad;
- replace 60-70% of devices and equipment of the Hydrometeorological Service with modern measuring technologies.

The experience of implementing the Program, as well as the experience of a number of other countries that have gone this way, have shown that such Programs require a strong state support, namely, the state investments in this area. However, the difficult economic situation in the country, did not allow to allocate the necessary volumes of state investments in this branch. As it was noted above, the part of the Program related to the technologies elaboration, was financed only at 30%, and capital assets costs did not allocate at all. In addition, the imperfect legislation on the development of small and medium-sized businesses, prevented manufactures of technologies, take loans for production. These circumstances lead to the fact that a number of aviation meteorological stations with significant financial revenues from a civil aviation purchase the automated meteorological stations of foreign production.

4.8. Other current issues.

At the moment, Ukraine is taking steps to bring its legislation closer to the European one. This also applies to metrology and standardization issues. In the new Ukrainian laws on Standardization and on Metrology there is no clear boundary between legal obligations and voluntary initiative. This creates the preconditions for different interpretations of the rules of the law in the legislatively regulated sectors by business entities on the one hand and representatives of the state metrological supervision body on the other one.

There was a problem of replacement or upgrading of devices and equipment developed within the framework of the Program of technical re-equipment. The works in this direction is carried out, but they should be strengthened.

5. Conclusion.

The twenty years of experience showed that the strategy for the development of the domestic industry of hydrometeorological instrumentation in the country has met the need of the Hydrometeorological Service and the ability of Ukrainian scientific and technical potential. The experience has also shown that the radical modernization of all direction of activities of the Hydrometeorological Service requires the significant investments from the state. Unfortunately, the Program of technical re-equipment has not been provided with the necessary investments failed, which greatly limited the effectiveness of the results of its implementation.

At present, the Hydrometeorological Service is developing the Strategy for the Development of the Hydrometeorological Service of Ukraine until 2030. The technical re-equipment of the system of observation, forecasting and maintenance of users will be a key part of the Strategy.

The Strategy provides for three areas of investment attraction:

- from the state budget of the country for the implementation of the target state program;
- partly, at the expense of the main users of hydrometeorological information and products;
- a loan of international financial institutions under state guarantees.